Prepared for

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Region 6
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TECHNICAL MEMORANDUM SUPPLEMENTAL NORTH MARSH AREA SITE INVESTIGATION AND EVALUATION OF ORIGINAL REMEDY

BAILEY SUPERFUND SITE ORANGE COUNTY, TEXAS

Submitted by:

Bailey Site Settlors Committee

Prepared by

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EXECUTIVE SUMMARY

This document has been prepared by GeoSyntec Consultants, Atlanta, Georgia (GeoSyntec), on behalf of the Bailey Site Settlors Committee (BSSC) to present the data obtained from supplemental site investigation activities in the North Marsh Area of the Bailey Superfund Site, located in Orange County, Texas. This work product is the result of Task 5, "Supplemental North Marsh Area Site Investigation and Evaluation of Original Remedy", of the "*Work Plan for Focused Feasibility Study, Revision 1*" [GeoSyntec, 15 August 1995] (hereafter referred to as FFS Work Plan).

The FFS Work Plan proposed that the original remedy and alternative disposal options for the North Marsh Area waste be evaluated. The original remedy presented in the Consent Decree for the site requires the North Marsh Area waste (tarry waste and underlying-affected sediment) to be excavated, stabilized, and placed into Pit A within the North Dike Area. Prior to placement of the stabilized material into Pit A, the pit would be enlarged and a perimeter berm would be constructed around the pit. A cap that is similar to the cap required for the North Dike Area would be constructed over the disposed material.

Following a review of the existing data for the North Marsh Area waste, GeoSyntec concluded that there was not sufficient data to adequately evaluate alternative disposal options for the waste material. Therefore, a supplemental site investigation of the North Marsh Area was implemented to collect and analyze samples of the tarry waste and underlying-affected sediment.

Based on a statistical evaluation of the analytical data for the North Marsh Area waste samples, chemical constituents are not present at hazardous levels when compared to TCLP regulatory levels. In addition, the data set was evaluated to have a normal distribution and is therefore considered representative of the North Marsh Area waste. Therefore, the North Marsh Area waste is considered non-hazardous and no more sampling is necessary.

Three disposal alternatives were developed based on the analytical results of the North Marsh Area waste samples. These alternatives are:

- Alternative 1 — Disposal in Pit A (Original Remedy)
- Alternative 2 — Disposal in the East Dike Area; and
- Alternative 3 — Off-Site Disposal.

The three alternatives were evaluated based on technical, economic, and regulatory considerations and USEPA's nine-point criteria for evaluating remedial alternatives. Based on this evaluation, Alternative 3 is considered the most desirable disposal option. This alternative includes:

- North Marsh Area waste excavation;
- possible on- or off-site pre-disposal stabilization;
- transportation of the waste material; and
- off-site disposal in a Class I industrial landfill (non-hazardous).

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1. INTRODUCTION

1.1 Terms of Reference

This document has been prepared by GeoSyntec Consultants, Atlanta, Georgia (GeoSyntec) on behalf of the Bailey Site Settlors Committee (BSSC) to present the data obtained from supplemental site investigation activities in the North Marsh Area of the Bailey Superfund Site, located in Orange County, Texas. This work product is the result of Task 5, "Supplemental North Marsh Area Site Investigation and Evaluation of Original Remedy", of the "*Work Plan for Focused Feasibility Study, Revision 1*" [GeoSyntec, 15 August 1995] (hereafter referred to as FFS Work Plan).

The supplemental site investigation activities were performed in accordance with the appropriate requirements of the following documents:

- Sampling and Analysis Plan for Supplemental Site Investigation for Focused Feasibility Study, Revision 1, (SAPSSI) [GeoSyntec, 17 August 1995];
- Final Sampling and Analysis Plan (SAP-HLA), [Harding Lawson Associates (HLA), October 1991];
- Final North Marsh Area Waste Sampling and Analysis Plan (NMWSAP-HLA), [HLA, November 1993;
- Health and Safety Plan (HASP), [Parsons Engineering Science, Inc. (Parsons ES), July 1995].

1.2 Project Background

The Bailey Superfund Site is located approximately three miles (five km) southwest of Bridge City in Orange County, Texas. The site was originally part of a tidal marsh near the confluence of the Neches River and Sabine Lake. In the early 1950s, Mr. Joe Bailey constructed two ponds (Pond A and Pond B) at the site as part of the Bailey Fish Camp. The ponds were reportedly constructed by dredging the marsh and piling sediments to form dikes along the north and east limits of Pond A (the North Dike Area and the East Dike Area). Between the time of construction (1950s) and the spring of 1971, Mr. Bailey used a variety of wastes (including industrial wastes, municipal solid waste, and construction debris) as fill material for these dikes.

In 1984, the USEPA proposed the site for inclusion on the National Priorities List (NPL). The site was placed on the NPL in 1986. A remedial investigation (RI) was completed for the site in October 1987, and a feasibility study (FS) was completed in April 1988. The RI concluded that: (i) the site has had no impact on drinking water; and (ii) in the unlikely event that any constituents were to migrate in the direction of ground water flow, it would take over 800 years for them to reach potable ground water. The shallow ground water beneath and adjacent to the site is saline and not suitable for human consumption. The closest public water supply well, located approximately 1.5 miles (2.4 km) northeast of the site, is estimated to be approximately 385 ft (117 m) deep. The nearest municipal water supply wells are located approximately 2.6 miles (4.2 km) northeast of the site and have a reported depth of approximately 585 ft (173 m). There has been no development in the project area, nor is it likely to be suitable for future development due to prohibitions against development in wetlands areas. No air emissions above ambient conditions were detected during air monitoring activities conducted during RI field activities.

The FS recommended in-situ solidification of the on-site waste as the preferred remedy for the site. USEPA selected this remedy in its Record of Decision (ROD), signed on 28 June 1988. The remediation area comprises the North Dike Area, East Dike Area, and the North Marsh Area. The North Dike Area is approximately 3,000 ft (914 m) long by 130 ft (40 m) wide, and the East Dike Area is approximately 1,200 ft (366 m) long by 220 ft (67 m) wide. Surficial tarry wastes are present in the North Marsh Area which borders the north side of the North Dike Area. These wastes extend from the edge of the North Dike Area to a distance of up to 150 ft (46 m) into the marsh.

A remedial design (RD) for the above remedy was developed by Harding Lawson Associates, Houston, Texas (HLA) and a construction contract for the implementation of the remedial action (RA) was awarded to Chemical Waste Management, Inc. (Chem Waste) in 1992. During initial attempts to solidify waste in the East Dike Area, Chem Waste encountered numerous difficulties attaining the specified performance parameters for the solidified waste. As a result of the difficulties, the RA was eventually suspended in early 1994. Remedial activities that were completed prior to the cessation of work include the construction of the dike around the East Dike Area of the site, and partial solidification of waste within that area.

After Chem Waste stopped work, the BSSC retained independent contractors and consultants to perform a pilot study to evaluate the feasibility of the selected remedy (i.e., in-situ solidification) at one location in the East Dike Area. The study indicated that solidification could be performed at that location in general conformance with the specifications. The study concluded, however, that to meet the specification requirements, conformance testing needed to be based on wet sampling of uncured material, followed by laboratory curing, rather than coring of material cured in-situ (as had initially been performed). Importantly, the study did not address the feasibility of solidification in other areas of the site. Data and information collected during the RA indicates that the waste in the North Dike Area is deeper and more heterogeneous than the waste in the area of the pilot study. Data obtained during the RA also indicates that waste constituents in the North Dike Area include municipal waste, rubber crumb, and tarry wastes which, based on both USEPA and industry experience, may be difficult and expensive to effectively solidify in-situ. If present in sufficient quantities, these constituents could render in-situ solidification technically infeasible.

Based on RA activities at the site to date, the BSSC concluded that successful site-wide solidification of waste at the site would be, at a minimum, expensive, time consuming, and difficult to implement. Solidification in accordance with the specifications may be technically infeasible in the North Dike Area. Recognizing this fact, USEPA requested that the BSSC further evaluate the feasibility of solidification of the North Dike Area and perform an FFS to identify whether more expedient and effective RA alternatives may be available.

Other reasons for performing the FFS at this time include: (i) developments over the past seven years in the materials and methods used to implement RA alternatives will allow consideration of remedial alternatives not available at the time the original FS was prepared; and (ii) data collected during conduct of the RD and RA have resulted in an improved understanding of subsurface conditions at the site in comparison to the understanding of conditions at the time the original FS was conducted.

2. OBJECTIVES

The original remedy for the North Marsh Area required the tarry waste and underlying-affected sediment (hereafter referred to as North Marsh Area waste) from the marsh to be removed, stabilized, and placed into Pit A within the North Dike Area. The eastern end of Pit A is shown in Figure 1. In the original remedy, improvements to the Pit A disposal area, including enlargement and construction of a perimeter berm, would be made prior to placement of waste in the pit. The disposal area would then be capped in a similar manner as other areas of the North Dike Area that contain waste.

In the FFS Work Plan, it was proposed that the original remedy for remediation of the North Marsh Area waste be re-evaluated and that potential alternative remedies be considered. Two alternative disposal options have been identified: (i) placement of marsh waste within the perimeter berm in the southern half of the East Dike Area, followed by capping of the area; and (ii) off-site disposal of the North Marsh Area waste at a commercial disposal facility.

Data regarding the chemical characteristics of the North Marsh Area waste are limited. More specifically, prior to the supplemental site investigation, adequate data did not exist that would allow preliminary waste profile sheets to be completed. Waste profile sheets are required to make decisions regarding the technical and regulatory feasibility of off-site disposal, and to obtain cost quotations for disposal. It was therefore necessary to collect additional data to fully characterize the North Marsh Area waste and evaluate the alternative disposal options for the North Marsh Area waste, as presented in the FFS Work Plan. The sampling and analytical program for the North Marsh Area was designed to provide data suitable for these purposes that would supplement previous data.

The results of the investigation were used to evaluate alternative disposal options for the North Marsh Area waste. The evaluation considered both the technical and regulatory feasibility of each alternative disposal option.

3. SAMPLING AND ANALYTICAL PROCEDURES

3.1 Sample Collection

On 10 August 1995, samples of the tarry waste and underlying-affected sediment (where possible) were collected from six locations within the North Marsh Area of the site. Sampling locations were selected to provide approximate uniform coverage of the waste, and to provide representative samples of the waste in terms of visual consistency. Sampling commenced from the west end of the waste area, and progressed towards the east. The first four locations were accessed using a small boat. The latter locations were accessed on foot since they were in drier areas of the marsh. Figure 1 indicates the sampling locations.

Samples were collected, using decontaminated tools and placed into laboratory prepared containers, in accordance with the SAPSSI. Due to the very oily and tarry nature of the marsh waste, it proved infeasible to re-use sampling tools. Therefore, sampling tools were used only once. Each sample was labeled, placed in a plastic bubble pack bag, and stored on ice in an insulated cooler for transportation to the analytical laboratory. Samples were shipped under chain-of-custody protocols to an analytical laboratory for chemical analyses and to a geoenvironmental laboratory for paint filter testing. Chemical analyses were performed by EcoSys, Norcross, Georgia, and paint filter testing was performed by GeoSyntec Consultants Environmental Lab, Atlanta, Georgia.

3.1.1 Sample Identification

Each samples was given a unique four part identification number that designated the following:

- Sampling Organization - GeoSyntec (G)
- General Area of the Site - North Marsh Area(NM)
- Sample Matrix - Waste (W) or Soil/Sediment (S)
- Location/Numerical Designation - Where more than one sample or duplicates were taken, samples were labeled A, B, etc.

For example, a sample with an identification code of G-NM-W-3A would indicate a waste sample taken by GeoSyntec in the North Marsh Area at location 3.

3.1.2 Sample Descriptions

Table 1 provides descriptions for samples collected on 10 August 1995 during the supplemental site investigation activities. This information includes approximate water depth at the time of sampling, sample matrix, visual description, and waste thickness.

3.2 Sample Analysis

Table 2 presents an analysis summary for the samples taken on 10 August 1995 for this supplemental site investigation. The following analyses with the representative methods were used on one or more samples (USEPA test methods given in parenthesis):

- Metals, Total and TCLP (Method 6010/7470);
- SVOC, Total and TCLP (Method 8270);
- VOC, Total and TCLP (Method 8260);
- Pesticides and PCBs, (Total and TCLP (Method 8080));
- Total Cyanide (Method 335.2);
- Total Fluoride (Method 340.2);
- Total Nitrate (Method 353.1);
- Total Solids (Method 160.3);
- Reactive Cyanide (Method 7.3.3.2);
- Reactive Sulfide (Method 7.3.4.1);

- Waste Profile - Corrosivity (Method 150.1); and

- Waste Profile - Ignitability (Method 150.1).

4. ANALYTICAL RESULTS

4.1 Summary of Analytical Results

Tables 3 and 4 present the results of analyses performed on the tarry waste and underlying-affected sediment samples collected from the North Marsh Area. Table 3 includes the laboratory results for samples collected on 10 August 1995 and samples collected by Harding Lawson Associates (HLA) in November 1993. Only compounds which were detected in at least one sample are presented in the table. Table 4 presents the maximum value, minimum value, and average concentrations for those compounds presented in Table 3, together with applicable regulatory limits. Laboratory data for the 10 August 1995 samples are presented in Appendix A (bound separately). Various tables included in Appendix A present a summary of the analytical results for these samples and prescribed regulatory levels.

4.2 Evaluation of Analytical Results

A statistical evaluation of the analytical data for the North Marsh Area waste samples collected during the supplemental site investigation demonstrates that:

- the constituents in the North Marsh Area waste are not present at hazardous levels when compared to TCLP regulatory levels, as prescribed in 40 CFR §261.24 (i.e., the North Marsh Area waste is non-hazardous); and

- the data set for the supplemental site investigation was evaluated to have a normal distribution and is considered representative of the North Marsh Area waste (i.e., no more sampling is necessary in the North Marsh Area).

Therefore, the North Marsh Area waste can be disposed in a Class I industrial waste landfill (non-hazardous), contingent on disposal facility-specific requirements (possibly pre-disposal stabilization).

The statistical evaluation was performed on analytical results for samples of the tarry waste and did not include results for the underlying-affected sediment (TCLP analyses were not performed on the underlying-affected sediment samples). Constituent concentrations for the excavated North Marsh Area waste (tarry waste and underlying-affected sediment) will be even less than the concentrations detected for only the tarry waste samples as a result of normal excavation and handling procedures that will occur during construction.

The statistical analysis was performed using methods presented in "*Chapter Nine - Sampling Plan, Test Methods for Evaluating Solid Waste*," [EPA/SW-846] (hereafter referred to as Chapter Nine of SW-846). This analysis is presented as Appendix B of this document.

Prior to performing the statistical evaluation, the results of the chemical analyses were compared to TCLP regulatory levels. One sample and its duplicate (G-NM-S-3A and 3B) marginally exceeded the TCLP regulatory level for 1,2 dichloroethane by 0.22 and 0.1 parts per million, respectively. In addition, one sample (G-NM-S-3A) slightly exceeded the TCLP regulatory level for benzene by 0.06 parts per million.

The statistical evaluation was therefore performed to assess whether the exceeding constituent concentrations are "*considered to be present in the waste at a hazardous level*", based on USEPA criteria presented in Chapter Nine of SW-846. The statistical evaluation is a two-step process that analyzes: (i) the statistical significance of the data set with respect to the presence of constituents at hazardous waste levels; and (ii) whether additional samples are necessary for the evaluation. Based on this evaluation, the constituents in the North Marsh Area waste are not present at hazardous levels (i.e., the North Marsh Area waste is non-hazardous), and the data set is considered representative of the North Marsh Area waste (i.e., no more sampling in the North Marsh Area is necessary).

5. IDENTIFICATION OF DISPOSAL OPTIONS

5.1 Introduction

Three disposal options were considered for the North Marsh Area waste. These alternatives are:

- disposal in Pit A (original remedy);
- disposal in the East Dike Area; and
- off-site disposal.

Each of these disposal options includes stabilization of the excavated North Marsh Area waste as a potential pre-disposal process. Pre-disposal stabilization of the excavated material may not be necessary or required depending on the physical properties (e.g., moisture content, viscosity) of the excavated material. Pre-disposal stabilization of the excavated waste material is addressed in more detail in Section 6 of this document.

The three disposal options are described in the following sections of this report.

5.2 Alternative 1: Disposal in Pit A (Original Remedy)

5.2.1 Description of Alternative

This alternative represents the original remedy for the disposal of North Marsh Area waste, as developed by HLA. Key components of this alternative are as follows:

- excavation of North Marsh Area waste;
- pre-disposal stabilization of excavated materials;
- improvements to Pit A-including enlargement of the perimeter berm;

- transportation of stabilized materials to Pit A;
- placement of stabilized materials into Pit A; and
- capping of the area in a similar manner to the other areas of the North Dike Area.

5.2.2 Economic Considerations

All three disposal options contain certain common elements that are considered baseline costs. These include excavation and handling of wastes and pre-disposal stabilization (if necessary). Alternative-specific costs for Alternative 1 are: (i) improvements to Pit A; (ii) placement of the stabilized materials into Pit A; and (iii) capping of Pit A. Based on a review of the original construction bids for this alternative (OH Materials and Sevenson Environmental Services), the order of magnitude cost estimate for the modifications to Pit A, placement of waste into the pit, and capping the pit (i.e., the alternative-specific items only) is $1,400,000.

5.2.3 Other Considerations

The following considerations are also relevant to the selection and implementation of Alternative 1:

- although the waste would be stabilized and capped, the waste material would remain on-site;
- following placement of the cap, Pit A would require long-term maintenance;
- this alternative would require a significant lead time for the preparation and improvements to Pit A; therefore, it is unlikely that this alternative could be executed during the 1995/1996 winter construction season, thereby causing the waste to remain in the North Marsh Area until the 1996/1997 winter construction season; the work at the site should be conducted during the

winter months so that the hurricane season is avoided and so that cooler temperatures result in improved material handling;

- existing wetlands at the site (Pit A) would be adversely affected by the construction operations; and

- a review of USEPA's nine-point criteria for evaluating remedial alternatives, as presented in "*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*" [EPA/540/G-89/004], was performed with respect to this alternative; based on this review, Alternative 1 would:
  - achieve and maintain overall protection of human health and the environment;
  - possibly comply with the site applicable or relevant and appropriate requirements (ARARs) (this criteria needs further consideration);
  - provide long-term effectiveness and permanence;
  - reduce the mobility of the waste and toxicity of leachate from the waste, and would increase the volume of the waste; and
  - not be implemented until the 1996/1997 winter construction schedule, therefore this alternative lacks short-term effectiveness; however, the alternative is considered implementable.

State and community acceptance were not evaluated as part of this review.

5.3 Alternative 2: Disposal in the East Dike Area

5.3.1 Description of Alternative

This alternative involves excavation of North Marsh Area waste and disposal in the southern part of the East Dike Area (previously solidified area). The North Marsh waste would be placed in lifts directly on top of the solidified portions of the East Dike Area. Key components of this alternative are as follows:

- excavation of North Marsh Area waste;

- pre-disposal stabilization of excavated materials (if necessary);
- grading and preparation of the selected East Dike Area disposal area;
- transportation of stabilized materials to the East Dike Area;
- placement of the stabilized materials into the prepared area; and
- capping of the area in a similar manner to the other areas of the East Dike Area.

5.3.2 Economic Considerations

Alternative-specific costs for Alternative 2 are: (i) the grading and preparation of the selected disposal area within the East Dike Area (this would likely be the area that was previously solidified); (ii) transportation of the stabilized materials to the East Dike Area; and (iii) placement of stabilized material into the prepared area. Capping of this area will be required even if the area is not used for marsh waste disposal, and is therefore not an alternative-specific cost.

Detailed cost estimates have not been prepared for this disposal option. However, based on a review of the alternative-specific components, costs for each component, except transportation of wastes to the East Dike Area, are likely to be less than the corresponding items for the preparation of Pit A. Therefore, for purposes of comparison, an order of magnitude cost of "less than $1,000,000" has been assumed for the alternative-specific components.

5.3.3 Other Considerations

The following considerations are also relevant to the selection and implementation of Alternative 2:

- although the waste would be stabilized and capped, the waste material would remain on-site;

- a cap will be constructed over the East Dike Area even if the North Marsh Area waste is not disposed in this area; therefore, long-term maintenance requirements and costs for the cap would not be directly attributed to the placement of the North Marsh Area waste in this area;

- it is unlikely that this alternative could be designed and constructed in time for the 1995/1996 winter construction season, thereby allowing the waste to remain in the North Marsh Area until the 1996/1997 winter construction season;

- existing wetlands at the site (Pit A) would not be adversely affected by construction operations; and

- a review of USEPA's nine-point criteria for evaluating remedial alternatives, as presented in "*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*" [EPA/540/G-89/004], was performed with respect to this alternative; based on this review, Alternative 2 would:
    - achieve and maintain overall protection of human health and the environment;
    - possibly comply with the site ARARs (this criteria needs further consideration);
    - provide long-term effectiveness and permanence;
    - reduce the mobility of the waste and toxicity of leachate from the waste, and would increase the volume of the waste; and
    - not be implemented until the 1996/1997 winter construction schedule, therefore this alternative lacks short-term effectiveness; however, the alternative is considered implementable.

State and community acceptance were not evaluated as part of this review.

5.4 Alternative 3: Off-Site Disposal

5.4.1 Identification of Off-Site Disposal Facilities

GeoSyntec has made preliminary contact with several disposal facilities located in proximity to the Bailey Superfund Site. These include: the Browning-Ferris Industries (BFI) facility in Anahuac, Texas; the BFI facility near Beaumont, Texas; the Chem Waste facility in Port Arthur, Texas; and the Chem Waste facility in Lake Charles, Louisiana.

Preliminary contact has been made with each facility to evaluate waste disposal requirements, and to assess the likelihood of each facility accepting the North Marsh Area waste either with or without pre-disposal stabilization. Based on information gathered from the disposal facilities, the BFI facility located in Anahuac, Texas appears to be the most viable candidate for off-site disposal of the North Marsh Area waste. This facility is a Class I industrial waste landfill (non-hazardous) and is located approximately 60 miles (100 km) from the site. In addition, the BFI-Anahuac facility has the capability to stabilize the waste at their facility prior to disposal in the landfill. Therefore, the waste could be stabilized off-site (if necessary) provided that the excavated North Marsh Area waste can be properly handled and transported without on-site pre-disposal stabilization.

For planning purposes, the BFI-Anahuac facility is considered as "preferred" for disposal of the North Marsh Area waste. The criteria used to establish this preference are:

- waste acceptance criteria;
- distance from the site;
- disposal costs; and.
- the facility's capability to perform waste stabilization.

5.4.2 Description of Alternative

This alternative involves excavation of the North Marsh Area waste and disposal at an off-site facility. Key components of this alternative are as follows:

- excavation of North Marsh Area waste;
- on-site pre-disposal stabilization of excavated materials, if necessary (or pre-disposal stabilization at the disposal facility following transportation);
- transportation of stabilized materials to the waste disposal facility; and
- off-site disposal.

5.4.3 Economic Considerations

Alternative-specific costs for Alternative 3 are: (i) transportation of stabilized material to the waste disposal facility; and (ii) disposal fees. The order of magnitude cost estimate for alternative-specific items only is approximately $500,000. This cost is based on the following assumptions:

- 6,000 yd^3 (4,600 m^3) of material (in-place volume based on 1994 Bid Schedule);
- pre-disposal stabilization of the excavated material will occur on site (cost savings will be realized if all or part of the excavated material does not require pre-disposal stabilization; potential cost savings may be realized if the pre-disposal stabilization occurs at the disposal facility); and
- 10 percent volume increase when stabilized.

5.4.4 Other Considerations

The following considerations are also relevant for the selection and implementation of Alternative 3:

- the North Marsh Area waste will be removed from the site, therefore long-term maintenance requirements and costs specifically for the North Marsh Area waste may not be necessary;

- this alternative could be executed during the 1995/1996 winter construction season;

- existing wetlands at the site (Pit A) would not be adversely affected by construction operations;

- if the wastes are not stabilized at the site, the time required for on-site activities may be reduced; and

- a review of USEPA's nine-point criteria for evaluating remedial alternatives, as presented in "*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*" [EPA/540/G-89/004], was performed with respect to this alternative; based on this review, Alternative 3 would:
  - achieve and maintain overall protection of human health and the environment;
  - possibly comply with the site ARARs (this criteria needs further consideration);
  - provide long-term effectiveness and permanence;
  - remove the waste from the site, would reduce the mobility of the waste and toxicity of leachate from the waste (if stabilized), and would increase the volume of the waste (only if pre-disposal stabilization is necessary); and
  - possibly be implemented during the 1995/1996 winter construction schedule, therefore this alternative provides short-term effectiveness.

State and community acceptance were not evaluated as part of this review.

6. WASTE STABILIZATION

6.1 Stabilization Requirements

Due to the physical and chemical characteristics of the waste, it is assumed that stabilization will be required as a pre-disposal step for the three alternatives. In the case of on-site disposal alternatives (Alternatives 1 and 2), stabilization is required to reduce material handling difficulties, and to increase the strength of the material and therefore its ability to support a cap.

In the case of off-site disposal (Alternative 3), stabilization may be required to reduce material handling difficulties and to assure compliance with paint filter liquids test criteria for land disposal of the waste. Although only two of the six samples of waste failed the paint filter liquids test, it is likely that the excavated material will have a high moisture content and may contain free liquids. Therefore, the material may require stabilization as a pre-disposal process.

6.2 Waste Stabilization Data

Several previous studies have been performed to evaluate the feasibility of stabilizing the North Marsh Area waste and other wastes from the site. These previous studies include:

- "Stabilization Evaluation Report," [HLA, February 1991] - this report, which was prepared after completion of the FS, expanded on the stabilization study performed as part of the FS; although this report did not specifically address the North Marsh Area waste, the additive evaluation presented in the report provides data that may be used to estimate additive requirements for stabilizing North Marsh Area waste; and

- "Final Report - Laboratory Test Result, Treatability Study, North Marsh Area," [GeoSyntec, 8 December 1994] - this report was prepared for Sevenson Environmental Services, Inc. (SES); SES used the study as the basis of their bid for the North Marsh Area remediation; this work was never implemented.

Based on the data provided in these reports, stabilization of the North Marsh Area waste can be achieved with a variety of additives, including: lime kiln dust, cement, bentonite, and mixtures of these additives. However, pre-disposal stabilization of the excavated North Marsh Area waste may not be necessary for Alternative 3.

7. CONCLUSIONS

Alternative 3 is considered the most desirable disposal option following an evaluation of technical, economic, and regulatory considerations and USEPA's nine-point criteria for evaluating remedial alternatives. Future activities for implementing Alternative 3 include:

- an evaluation of the following: (i) time necessary to develop the remedial design, receive regulatory approval, and negotiate a contract (evaluate performing the work during the 1995/1996 winter construction season, if possible); (ii) USEPA confirmation of the data evaluation presented in this report so that the North Marsh Area waste can be disposed in a Class I industrial landfill (non-hazardous); (iii) opinion of remediation costs; (iv) on-site or off-site pre-disposal stabilization; and (v) disposal facility selection; and

- development of a work plan and schedule to execute the elements of the alternative during the 1995/1996 winter construction season.

TABLES

Table 1
Summary of Sample Visual Descriptions

Sample Location	Sample Identification	Approximate Water Depth	Sample Matrix	Sample Desciption	Waste Thickness
1	G-NM-W-1	2.5 feet	Waste	Dark gray and black tarry WASTE of gum-like consistency. Sample contained some sediment.	Approximately 3 inches
	G-NM-S-1	2.5 feet	Soil\Sediment	Dark brown and gray peaty SILT with rootlets and some vegetation. Sample was taken immediately below waste interface (3" to 9" below top of waste).	N/A
2	G-NM-W-2	2 to 3 feet	Waste	Black tarry WASTE of streaky gum-like consistency. Sample contained some sediment.	Approximately 2 inches
	G-NM-S-2	2 to 3 feet	Soil\Sediment	Dark gray SILT. Sample was taken immediately below waste interface (3" to 8" below top of waste).	N/A
3	G-NM-W-3A and 3B	2 to 2.5 feet	Waste	Black viscous oil-like WASTE (material was just pourable). Large oily sheen appeared at surface when material was disturbed.	Estimated at 4 to 6 inches
	G-NM-S-3	2 to 2.5 feet	Soil/Sediment	Sample abandoned - waste was too thick and viscous to retrieve adequate quantity of soil/sediment.	N/A
4	G-NM-W-4	2.5 feet	Waste	Black, very viscous, tarry, oily WASTE. Some oily sheen at surface during sampling.	Approximately 6 inches
	G-NM-S-4	2.5 feet	Soil/Sediment	Soft gray silty CLAY. Sample was taken immediately below waste interface (6" to 9" below top of waste).	N/A
5	G-NM-W-5	Sample taken at water line	Waste	Black, tarry, elastic WASTE with stiff, asphalt-like consistency.	Waste was piled from 1" to 18" high.
	G-NM-S-5	2.5 feet	Soil/Sediment	Gray SILT with rootlets and some vegetation. Sample was taken in creek channel immediately adjacent to waste.	N/A
6	G-NM-W-6	2 to 3 inches	Waste	Black, tarry, elastic WASTE with stiff, asphalt-like consistency.	Waste was piled from 1" to 18" high.
	G-NM-S-6	2 to 3 inches	Soil/Sediment	Gray SILT with rootlets and some vegetation. Sample was taken immediately adjacent to waste pile.	N/A

Table 2
Summary of Analyses

Location	Sample ID	Parameter Matrix/Method	Total Cyanide 335.2	Fluoride 340.2	Nitrate 353.1	Metals 6010/7470	VOC 8260	TCLP-Metals 6010/7470	TCLP-Pesticides 8080	TCLP-VOC 8260	Total Solids 160.3	Waste Profile-Corrosivity 150.1
1	G-NM-W-1	Waste										
	G-NM-S-1	Soil										
2	G-NM-W-2	Waste										
	G-NM-S-2	Soil										
3	G-NM-W-3A	Waste										
	G-NM-S-3A	Soil										
	G-NM-W-3B	Waste										
	G-NM-S-3B	Soil										
4	G-NM-W-4	Waste										
	G-NM-S-4	Soil										
5	G-NM-W-5	Waste										
	G-NM-S-5	Soil										
6	G-NM-W-6	Waste										
	G-NM-S-6	Soil										
QA Samples	G-NM-RB	Rinse Blank										
	G-NM-FB (x2)	Field Blank										
	G-NM-TB	Trip Blank										

Note: Shaded areas represent analysis performed on sample.

Table 2 (continued)
Summary of Analyses

		Parameter	Waste Profile-Ignitability	SVOC	Pesticides	PCB's	Reactive Cyanide	Reactive Sulfide	TCLP-SVOC	Paint Filter	Comments
Location	Sample ID	Matrix/Method	1010	8270	8080	8080	7.3.3.2	7.3.4.1	8270		
1	G-NM-W-1	Waste									
	G-NM-S-1	Soil									
2	G-NM-W-2	Waste									
	G-NM-S-2	Soil									
3	G-NM-W-3A	Waste									
	G-NM-S-3A	Soil									Sample not collected
	G-NM-W-3B	Waste									
	G-NM-S-3B	Soil									Sample not collected
4	G-NM-W-4	Waste									
	G-NM-S-4	Soil									
5	G-NM-W-5	Waste									
	G-NM-S-5	Soil									
6	G-NM-W-6	Waste									
	G-NM-S-6	Soil									
QA Samples	G-NM-RB	Rinse Blank									Equipment rinsate
	G-NM-FB (x2)	Field Blank									
	G-NM-TB	Trip Blank									

Note: Shaded areas represent analysis performed on sample.

Table 3
Existing Analytical Data for North Marsh

Sample ID		G-NM-W-1	G-NM-S-1	G-NM-W-2	G-NM-S-2	G-NM-W-3A	G-NM-W-3B	G-NM-W-4	G-NM-S-4	G-NM-W-5	G-NM-W-6	G-NM-S-6	B (black waste)	B-Dup	A (red waste)	A-Dup	A1[1]	A1-Dup[1]	B1[1]	B1-Dup[1]
Sampling Date		10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	10-Aug-95	Nov-93	Nov-93	Nov-93	Nov-93	Nov-93	Nov-93	Nov-93	Nov-93
METALS	**Units**																			
Barium	mg/kg	9	23 4	NA[2]	NA	10	9	NA	NA	NA	98	150	8	12 2	9 1	8 8	NA	NA	NA	NA
Chromium	mg/kg	6	6 4	NA	NA	4	11	NA	NA	NA	15	12	6	4	17	16	NA	NA	NA	NA
Copper	mg/kg	5	4 3	NA	NA	4	9	NA	NA	NA	6	6	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/kg	5	6 4	NA	NA	7	5	NA	NA	NA	12	20	ND[3]	10	ND	ND	NA	NA	NA	NA
Nickel	mg/kg	3	5 9	NA	NA	2	2	NA	NA	NA	1	2	NA	NA	NA	NA	NA	NA	NA	NA
VOLATILE ORGANIC COMPOUNDS																				
Benzene	mg/kg	5 4	0 057	NA	NA	21	13	NA	NA	NA	>0 500	>0 005	3 3	0 17	33	44	75	60	17	2 2
1,2-dichloroethane	mg/kg	1 8	>0 005	NA	NA	16	9 7	NA	NA	NA	>0 500	>0 005	ND	ND	ND	ND	45	41	2 8	ND
1,2-dichloropropane	mg/kg	>0 500	>0 005	NA	NA	1	0 64	NA	NA	NA	>0 500	>0 005	ND	ND	21	27	ND	ND	ND	ND
E-benzene	mg/kg	12	0 051	NA	NA	31	18	NA	NA	NA	>0 500	>0 005	16	0 7	62	80	120	94	56	7 7
Styrene	mg/kg	13	>0 005	NA	NA	51	30	NA	NA	NA	>0 500	>0 005	10	ND	73	110	150	120	46	5 6
Toluene	mg/kg	4 5	0 027	NA	NA	15	8 9	NA	NA	NA	>0 500	>0 005	3 6	0 1	22	29	ND	ND	ND	ND
Xylenes	mg/kg	4 7	0 013	NA	NA	15	9 6	NA	NA	NA	>0 500	>0 005	4 2	0 16	41	54	74	56	34	4 1
SEMIVOLATILE ORGANIC COMPOUNDS																				
Anthracene	mg/kg	2 29 J	>0 990	NA	NA	>198	>198	NA	NA	NA	>9 90	>9 90	ND	ND	ND	ND	ND	ND	ND	ND
di-n-Butyl Phthalate	mg/kg	>0 990	6 98	NA	NA	>198	>198	NA	NA	NA	>9 90	>9 90	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyl Naphthalene	mg/kg	3 61 J	>0 990	NA	NA	177	179	NA	NA	NA	>9 90	>9 90	ND	ND	ND	ND	200	ND	ND	ND
Naphthalene	mg/kg	7 3 J	>0 990	NA	NA	349	344	NA	NA	NA	>9 90	>9 90	200	ND	220	200	310	200	ND	ND
Phenanthrene	mg/kg	3 72 J	>0 990	NA	NA	>198	>198	NA	NA	NA	>9 90	>9 90	ND	ND	ND	ND	ND	ND	ND	ND
TCLP-METALS																				
Barium	mg/L	0 84	NA	0 66	NA	1	0 86	0 66	NA	0 47	0 63	NA	NA	NA	NA	NA	ND	ND	ND	ND
Lead	mg/L	>0 015	NA	>0 015	NA	>0 015	0 14	>0 015	NA	>0 015	>0 015	NA	NA	NA	NA	NA	ND	ND	ND	ND
TCLP-ORGANIC COMPOUNDS																				
Benzene	mg/L	0 11	NA	0 24	NA	0.56	0 48	0.24	NA	>0 01	>0 010	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cresol	mg/L	0 087	NA	0 066	NA	>0 50	>0 50	>0 50	NA	>0 050	>0 050	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichloroethane	mg/L	0 05	NA	0 32	NA	0.72	0.6	0 21	NA	>0 01	>0 010	NA	NA	NA	NA	NA	NA	NA	NA	NA
MISCELLANEOUS																				
Chlorides	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	800	790	2230	2230
Corrosivity	Standard Units	6 2	NA	5 6	NA	5 4	5 5	5 4	NA	6 7	7 1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide, Total	mg/kg	0 065	>0 025	NA	NA	0 194	0 244	NA	NA	NA	>0 025	>0 025	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide, Reactive	mg/kg	<25	NA	<25	<25	<25	NA	<25	NA	<25	<25	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	mg/kg	31 4	13 6	NA	NA	20 4	13 9	NA	NA	NA	38 7	27 4	NA	NA	NA	NA	NA	NA	NA	NA
Ignitability	Fahrenheit	>210	NA	>210	NA	>210	>210	>210	NA	>210	>210	NA	NA	NA	NA	NA	NA	NA	NA	NA
Oil and Grease	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	160	82	86	85
Paint Filter	Pass/Fail	Fail	Pass	Fail	Pass	Pass	NA	Pass	Pass	Pass	Pass	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH	Standard Units	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7 04	6 97	6 95	6 95
Pour Point	Fahrenheit	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	75	NA	90	NA
Sulfates	ppm	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	73	74	163	140
Sulfides, Reactive	mg/kg	<30	NA	<30	NA	<30	<30	<30	NA	<30	<30	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOC	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	56	57
TPH	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	150	80	36	69

[1] - Information could not be found regarding the location of the samples
[2] - NA = Not Analyzed
[3] - ND = Not Detected

Table 4
Summary of Analytical Data for North Marsh

Parameter	Units	Applicable Regulatory Value	Maximum Value (mg/kg)	Minimum Value (mg/kg)	Average Value (mg/kg)	Total Samples (mg/kg)
METALS						
Barium	mg/kg	NA[3]	150.00	8.00	33.75	10
Chromium	mg/kg	NA	17.00	4.00	9.74	10
Copper	mg/kg	NA	9.00	4.00	5.72	6
Lead	mg/kg	NA	20.00	0.00	6.54	10
Nickel	mg/kg	NA	5.90	1.00	2.65	6
VOLATILE ORGANIC COMPOUNDS						
Benzene	mg/kg	10 mg/kg[1]	75.00	0.00	19.58	14
1,2-Dichloroethane	mg/kg	6 mg/kg[1]	45.00	0.00	8.31	14
1,2-Dichloropropane	mg/kg	18 mg/kg[1]	27.00	0.00	3.55	14
Ethylbenzene	mg/kg	10 mg/kg[1]	120.00	0.00	35.53	14
Styrene	mg/kg	NA	150.00	0.00	43.47	14
Toluene	mg/kg	10 mg/kg[1]	29.00	0.00	5.94	14
Xylenes	mg/kg	30 mg/kg[1]	74.00	0.00	21.20	14
SEMIVOLATILE ORGANIC COMPOUNDS						
Anthracene	mg/kg	3.4 mg/kg[1]	0.00	0.00	0.00	14
di-n-Butyl Phthalate	mg/kg	28 mg/kg[1]	6.98	0.00	0.50	14
2-Methylnaphthalene	mg/kg	NA	200.00	0.00	39.71	14
Naphthalene	mg/kg	5.6 mg/kg[1]	349.00	0.00	130.21	14
Phenanthrene	mg/kg	5.6 mg/kg[1]	0.00	0.00	0.00	14
TCLP-METALS						
Barium	mg/L	100 mg/L[2]	1.00	0.00	0.47	11
Lead	mg/L	5 mg/L[2]	0.14	0.00	0.01	11
TCLP-ORGANICS						
Benzene	mg/L	0.5 mg/L[2]	**0.56**	0.00	0.23	7
Cresol	mg/L	200 mg/L[2]	0.09	0.00	0.02	7
1,2-Dichloroethane	mg/L	0.5 mg/L[2]	**0.72**	0.00	0.27	7
MISCELLANEOUS						
Chlorides	mg/kg	NA	2,230.00	790.00	1,512.50	4
Corrosivity	Standard Units	NA	7.10	5.40	5.99	7
Cyanide, Reactive	mg/kg	NA	0.00	0.00	0.00	7
Cyanide, Total	mg/kg	NA	0.24	0.00	0.08	6
Fluoride	mg/kg	NA	38.70	13.60	24.23	6
Ignitability	Fahrenheit	NA	210.00	210.00	210.00	7
Oil and Grease	mg/kg	NA	160.00	82.00	103.25	4
pH	Standard Units	NA	7.04	6.95	6.98	4
Pour Point	Fahrenheit	NA	90.00	75.00	82.50	2
Sulfates	ppm	NA	163.00	73.00	112.50	4
Sulfides, Reactive	mg/kg	NA	0.00	0.00	0.00	7
TOC	mg/kg	NA	57.00	0.00	28.25	4
TPH	mg/kg	NA	150.00	36.00	83.75	4

[1] - Universal treatment standard (LDR) set in 40 CFR 268.48

[2] - Toxicity characteristic level set in 40 CFR 261.24

[3] - Not Applicable

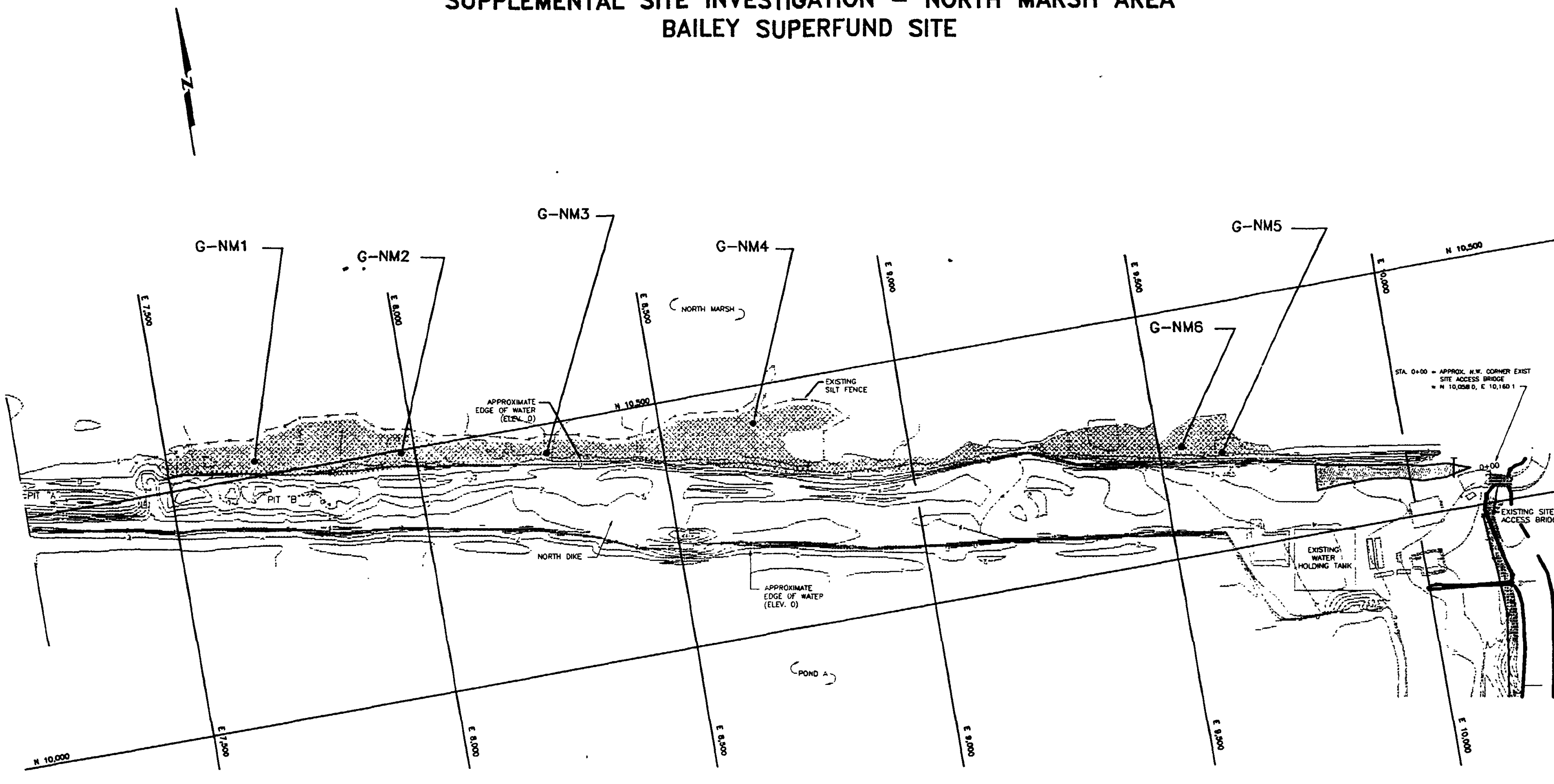
FIGURE

APPENDIX A

LABORATORY TEST RESULTS

(Bound Separately)

NORTH MARSH WASTE AND SEDIMENT SAMPLING LOCATIONS
SUPPLEMENTAL SITE INVESTIGATION - NORTH MARSH AREA
BAILEY SUPERFUND SITE



LEGEND

•G-NM6 DESIGNATION AND APPROXIMATE LOCATION OF WASTE AND SEDIMENT SAMPLES

NORTH MARSH WASTE

NOTES:

BASE MAP PREPARED BY HARDING LAWSON ASSOCIATES, HOUSTON, TEXAS.

GEOSYNTEC CONSULTANTS
ATLANTA, GA

PROJECT NO.	GA3913-04	FIGURE NO.	FIGURE 1
DOCUMENT NO.	GA951094	FILE NO.	3913F002

APPENDIX B

STATISTICAL CALCULATIONS

Written by: Tom Sargent Jr. Date: 95/09/26 Reviewed by: DBW Date: 95/9/27

Client: Bailey Tank Project: Bailey Project/Proposal No.: GE3913 Task No.: 5

The following calculations are based on equations in SW-846, chapter NINE. A summary table copied from the SW-846 is attached. Worksheets 1 and 2 for benzene and 1,2-dichloroethane are copies of spreadsheets used for calculations. TS

The TCLP data used in these calculations are taken from supplemental site investigation data. Based on this data, benzene and 1,2-dichloroethane are the constituents of concern. The data is as follows:

(mg/L)

Sample #	Benzene	1,2-dichloroethane
1	0.11	0.05
2	0.24	0.32
3A	0.56	0.72
Duplicate (not used in calcs) → 3B	0.48	0.60
4	0.24	0.21
5	<0.01	<0.01
6	<0.01	<0.01

(<0.01 indicates a non-detect. The detection level, 0.01, will be carried through in the calcs.)

The SW-846 recommends using preliminary data to ~~estimate~~ calculate the number of samples to be collected. Since we do not have preliminary data, we will use the 6 results. TWS

Benzene:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i = \frac{(0.11 + 0.24 + 0.56 + 0.24 + 0.01 + 0.01)}{6}$$

$$\boxed{\bar{X} = 0.195}$$

$$s^2 = \left[\sum_{i=1}^{n} x_i^2 - \left(\left(\sum_{i=1}^{n} x_i\right)^2\right)/n\right] / n-1$$

$$= \left[(0.11)^2 + (0.24)^2 + (0.56^2) + (\cancel{0.48}\ 0.24)^2 + (\cancel{0.24}\ 0.01)^2 + (0.01)^2 - \frac{(0.11 + 0.24 + 0.56 + 0.24 + 0.01 + 0.01)^2}{6} \right] / 5$$

Written by: Tom Sargent Jr. Date: 95/09/26 Reviewed by: DBW Date: 95/9/27

Client: Bailey Task Project: Bailey Project/Proposal No.: GE3913 Task No.: 5

$$\boxed{S^2 = 0.043}$$

$$\boxed{S = 0.206}$$

$t_{0.20} = 1.476$ (tabulated value from SW-846)

$RT = 0.50$ (regulatory value from 40 CFR 261.24)

$$\Delta = RT - \bar{X}$$

$$0.50 - 0.195 = 0.305$$

$$\boxed{\Delta^2 = 0.0930}$$

$$n_1 = \frac{t_{0.20}^2 S^2}{\Delta^2} = \frac{(1.476)^2 (0.043)}{0.0930} = \boxed{0.998}$$

This number indicates that one sample should be taken if the next calculations show the waste to be hazardous.

$$CI = \bar{X} \pm t_{0.20} S_{\bar{X}} \qquad S_{\bar{X}} = S/\sqrt{n} = 0.206/\sqrt{6}$$

$$= 0.195 \pm (1.476)(0.08425) \qquad S_{\bar{X}} = 0.08425$$

$$= 0.195 \pm 0.1243$$

$$UCI = 0.3193$$

TNS

Since $UCI < RT$, it is definitively concluded that benzene is not considered to be present in the tarry fraction of the North Marsh area waste at a hazardous level. (The North Marsh waste is nonhazardous with respect to benzene.

Written by: Tom Sargent Jr. Date: 95 / 09 / 26 Reviewed by: NBW Date: 95 / 9 / 27

Client: Bailey Taste Project: Bailey Project/Proposal No.: GE3913 Task No.: 5

1,2 - dichloroethane:

The same equations used for benzene are used for 1,2-dichloroethane.

$\bar{X} = 0.220$

$s^2 = 0.075$

$s = 0.275$

$t_{0.20} = 1.476$

$RT = 0.50$

$\Delta = 0.28$

$n_1 = 2.096$

Again, this shows that 2 extra samples would need to be taken if the next calculations indicate that the waste is hazardous.

$s_{\bar{x}} = 0.112$

$CI = 0.22 \pm 0.17$

$UCI = 0.39$

Since UCI < RT, it is definitively concluded that 1,2-dichloroethan is not considered to be present in the tarry fraction of the North Marsh area waste at a hazardous level. (The North Marsh waste is nonhazardous with respect to 1,2 - dichloroethane.

TNS

Written by: Tom Sargent Jr. Date: 95 / 09 / 26 Reviewed by: DBW Date: 95 / 9 / 27

Client: Bailey Tozle Project: Bailey Project/Proposal No.: GE3913 Task No.: 5

The data set for each constituent of concern can also be tested to see if it fits a normal distribution. One way to do this is the W test developed by Shapiro and Wilk. It is described on p. 158 in Statistical Methods for Environmental Pollution Monitoring by Gilbert.

The basis of the test is to determine whether a calculated W value is greater than a tabulated quantile W value. The data is ordered from ~~big~~ lowest to highest.

For benzene:

$x_1 = 0.01$
$x_2 = 0.01$
$x_3 = 0.11$
$x_4 = 0.24$
$x_5 = 0.24$
$x_6 = 0.56$

$$W = \frac{1}{d}\left[\sum_{i=1}^{k} a_i \left(x_{[n-i+1]} - x_i\right)\right]^2$$

where

$$d = \sum_{i=1}^{n} (x_i - \bar{x})^2$$

$$= (0.01-0.195)^2 + (0.01-0.195)^2 + (0.11-0.195)^2 + (0.24-0.195)^2 + (0.24-0.195)^2 + (0.56-0.195)^2$$

$$\boxed{d = 0.213}$$

$k = n/2 = 6/2 = 3$ (when n = even #)

tabulated values
$a_1 = 0.6431$
$a_2 = 0.2806$
$a_3 = 0.0875$

$$W = \frac{1}{0.213}\left[0.6431(0.56-0.01) + (0.2806)(0.24-0.01) + (0.0875)(0.24-0.\ldots\right.$$

$$\boxed{W = 0.869}$$

The tabulated W for $\alpha = 0.01$ is 0.713. Since the calculated W is greater than the tabulated W, it can be concluded that the normal distribution may be a reasonable approximation for this set of data which reflects benzene concentrations (TCLP) in the tarry fraction of the North Marsh Waste

Written by: Tom Sargent Jr. Date: 95 / 09 / 26 Reviewed by: DBW Date: 95 / 9 / 27

Client: Bailey Task Project: Bailey Project/Proposal No.: GE3913 Task No.: 5

For 1,2-dichloroethane:

The same calculations are performed that were performed for benzene.

$$d = 0.377$$

$$W = 0.826$$

$$W_{tables}\ [\alpha = 0.01] = 0.713$$

The tabulated W for $\alpha = 0.01$ is less than the calculated W value. Thus it can be concluded that the normal distribution may be a reasonable approximation for this set of data which reflects 1,2-dichloroethane concentrations (TCLP) in the tarry fraction of the North Marsh Waste.

TABLE 9-1. BASIC STATISTICAL TERMINOLOGY APPLICABLE TO SAMPLING PLANS FOR SOLID WASTES

Terminology	Symbol	Mathematical equation	(Equation)
• Variable (e.g., barium or endrin)	x	—	
• Individual measurement of variable	x_i	—	
• Mean of all possible measurements of variable (population mean)	μ	$\mu = \frac{\sum_{i=1}^{N} x_i}{N}$, with N = number of possible measurements	(1)
• Mean of measurements generated by sample (sample mean)	$\bar{x}$	<u>Simple random sampling and systematic random sampling</u> $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$, with n = number of sample measurements	(2a)
		<u>Stratified random sampling</u> $\bar{x} = \sum_{k=1}^{r} W_k \bar{x}_k$, with $\bar{x}_k$ = stratum mean and W_k = fraction of population represented by Stratum k (number of strata [k] range from 1 to r)	(2b)
• Variance of sample	s^2	<u>Simple random sampling and systematic random sampling</u> $s^2 = \frac{\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2/n}{n - 1}$	(3a)
		<u>Stratified random sampling</u> $s^2 = \sum_{k=1}^{r} W_k s_k^2$, with s_k^2 = stratum variance and W_k = fraction of population represent by Stratum k (number of strata [k] ranges from 1 to r)	(3b)

from SW-846

TABLE 9-1. (Continued)

Terminology	Symbol	Mathematical equation	(Equation)
• Standard deviation of sample	s	$s = \sqrt{s^2}$	(4)
• Standard error (also standard error of mean and standard deviation of mean) of sample	$s_{\bar{x}}$	$s_{\bar{x}} = \frac{s}{\sqrt{n}}$	(5)
• Confidence interval for μ[a]	CI	$CI = \bar{x} \pm t_{.20}\, s_{\bar{x}}$, with $t_{.20}$ obtained from Table 2 for appropriate degrees of freedom	(6)
• Regulatory threshold[a]	RT	Defined by EPA (e.g., 100 ppm for barium in elutriate of EP toxicity)	(7)
• Appropriate number of samples to collect from a solid waste (financial constraints not considered)	n	$n = \frac{t^2_{.20}s^2}{\Delta^2}$, with $\Delta = RT - \bar{x}$	(8)
• Degrees of freedom	df	$df = n - 1$	(9)
• Square root transformation	---	$X_i + 1/2$	(10)
• Arcsin transformation	---	Arcsin p; if necessary, refer to any text on basic statistics; measurements must be converted to percentages (p)	(11)

[a]The upper limit of the CI for μ is compared with the applicable regulatory threshold (RT) to determine if a solid waste contains the variable (chemical contaminant) of concern at a hazardous level. The contaminant of concern is not considered to be present in the waste at a hazardous level if the upper limit of the CI is less than the applicable RT. Otherwise, the opposite conclusion is reached.

from SW-846

Worksheet 1

The purpose of this worksheet is to assist in evaluating disposal options for a given waste based on the toxicity hazard characteristic. It will also evaluate whether the set of data can be approximated by the normal distribution.

Area	North Marsh
Name	Benzene
Data (mg/L)	0.01
	0.01
	0.11
	0.24
	0.24
	0.56

Number of Sample Points	n	6
Average of Results	x-bar	0.20
Variance	s^2	0.04
Standard Deviation	s	0.21
Standard Error	$s_{x\text{-bar}}$	0.08
Tabulated "t" value	$t_{0.20}$	1.4760
Upper Confidence Interval	UCI	0.32
Regulatory Level (mg/L)	RT	0.50
Number of samples needed	n'	1.00
"W" value	W	0.87
Tabulated "W" value	W_{val}	0.7130
Hazardous by Toxicity?		NO
Normally Distributed?		YES

Number of Sample Points	n	Total number of sample points in data set
Average of Results	x-bar	Sum of results divided by n
Tabulated "t" value	$t_{0.20}$	Taken from Chapter 9, SW-846 (80% confidence)
Upper Confidence Interval	UCI	Upper limit of true mean with 80% confidence
Regulatory Level	RT	Taken from 40 CFR 268.42
Number of samples needed	n'	Total samples to be collected from the waste
"W" value	W	Indicator for determination of normal distribution
Tabulated "W" value	W_{val}	Taken from Gilbert, 1987
Hazardous by Toxicity?		Hazardous if RT<UCI
Normally Distributed?		Normal if $W>W_{val}$

Bailey Superfund Site
GE 3913
6 October 1995
STAT_BLY.XL1

Worksheet 2

The purpose of this worksheet is to assist in evaluating disposal options for a given waste based on the toxicity hazard characteristic. It will also evaluate whether the set of data can be approximated by the normal distribution.

Area	North Marsh
Name	1,2-dichloroethane
Data (mg/L)	0.01
	0.01
	0.05
	0.21
	0.32
	0.72

Number of Sample Points	n	6
Average of Results	x-bar	0.22
Variance	s^2	0.08
Standard Deviation	s	0.27
Standard Error	$s_{x\text{-bar}}$	0.11
Tabulated "t" value	$t_{0.20}$	1.4760
Upper Confidence Interval	UCI	0.39
Regulatory Level (mg/L)	RT	0.50
Number of samples needed	n'	2.10
"W" value	W	0.82
Tabulated "W" value	W_{val}	0.7130
Hazardous by Toxicity?		NO
Normally Distributed?		YES

Number of Sample Points	n	Total number of sample points in data set
Average of Results	x-bar	Sum of results divided by n
Tabulated "t" value	$t_{0.20}$	Taken from Chapter 9, SW-846 (80% confidence)
Upper Confidence Interval	UCI	Upper limit of true mean with 80% confidence
Regulatory Level	RT	Taken from 40 CFR 268.42
Number of samples needed	n'	Total samples to be collected from the waste
"W" value	W	Indicator for determination of normal distribution
Tabulated "W" value	W_{val}	Taken from Gilbert, 1987
Hazardous by Toxicity?		Hazardous if RT<UCI
Normally Distributed?		Normal if $W>W_{val}$

APPENDIX D
ANALYSIS OF TECHNICAL EQUIVALENCY

Evaluation of Outflow
Due to Infiltration Through the Cap System

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: BSCC Project: Bailey Superfund Project/Proposal #: GE3913 Task #: Ø8

TITLE OF COMPUTATIONS Infiltration Analyses for NAA, ORD, and PRA Bailey Superfund Site

COMPUTATIONS BY: Signature Majdi Ahmed Othman 9 Jan 1996 DATE

Printed Name and Title MAJDI A. OTHMAN PROJECT ENGINEER

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer) Signature R Neil D 19 Jan 96 DATE

Printed Name and Title R. NEIL DAVIES. SENIOR PROJECT ENGINEER

COMPUTATIONS CHECKED BY: Signature R Neil D 19 Jan 96 DATE

Printed Name and Title R. NEIL DAVIES SENIOR PROJECT ENGINEER

COMPUTATIONS BACKCHECKED BY: (Originator) Signature Majdi Ahmed Othman 19 Jan 1996 DATE

Printed Name and Title Majdi A. Othman Project Engineer

APPROVED BY: (PM or Designate) Signature R Neil D 19 Jan 96 DATE

Printed Name and Title R. NEIL DAVIES. PROJECT MANAGER

APPROVAL NOTES: Approved for use in the FFS.

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

GA910096 91.01.21

Written by: MAG Date: 96/1/19 Reviewed by: RTW Date: 96/1/19

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE 3913 Task No.: 08

INFILTRATION ANALYSES FOR ORIGINAL REMEDIAL DESIGN AND POTENTIAL REMEDIAL ALTERNATIVE
BAILEY SUPERFUND SITE
ORANGE COUNTY, TEXAS

Written by: MAO Date: 96/1/19 Reviewed by: END Date: 96/1/19

Client: BSCC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: 08

INTRODUCTION AND PURPOSE OF ANALYSES

The original remedial design (ORD) for the Bailey superfund Site consisted of solidifying the waste and then capping the waste with a compacted clay cap. Solidification of the entire waste areas has been shown to be technically infeasible and therefore, alternative remedies were considered. A potential remedial alternative (PRA) considered is a light weight cap, consisting of geosynthetic and soil layers, to be placed on the unsolidified waste. Demonstration of equivalency of the PRA to the ORD is required.

As part of this demonstration, source flux out of the waste for each remedy is calculated. This source flux is a function of the rate of rainwater infiltration through the cap and out of the waste.

The purpose of the analyses presented herein is to estimate percolation through the cap and out of the waste for the ORD and PRA.

Written by: MAO Date: 96/1/19 Reviewed by: [illegible] Date: 96/1/19

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: Ø8

DESCRIPTION OF THE USEPA HELP MODEL

The United States Environmental Protection Agency (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) was used to perform the percolation analyses for the ORD and the PRA.

The HELP model simulates hydrologic processes for a landfill by performing daily, sequential water budget analyses using a quasi-two-dimensional, deterministic approach [Schroeder et al., 1994a, 1994b]. The HELP model is ordinarily used in the interactive mode and contains a broad meteorological and geotechnical database. The hydrologic factors considered in the HELP model include precipitation, surface-water storage (i.e., storage as snow), interception, surface evaporation, runoff, snow melting, infiltration, vegetation quality, evaporative zone depth, plant transpiration, soil evaporation, temperature, solar radiation, soil water storage, unsaturated flow, saturated flow, vertical drainage, lateral drainage, and vertical percolation through barrier layers.

Written by: MAO Date: 96 / 1 / 19 (YY MM DD) Reviewed by: [initials] Date: 96 / 1 / 19 (YY MM DD)

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE 3913 Task No.: 08

CROSS-SECTIONS ANALYZED

ORI

- 6-in. thick topsoil layer.
- 2.5-ft thick layer of compacted low-permeability soil.
- 2-ft thick layer of general fill.
- 5-ft thick layer of solidified waste. (note: it is estimated based on test pits that the thickness of waste is between 0 to 12 ft. On average, it is 5 to 6 ft).

PRA

9-in. thick topsoil layer.

- 200-mil thick geocomposite drainage layer consisting of a geonet with a nonwoven geotextile bonded to it from each side.
- 60-mil thick polyethylene geomembrane.
- 0.5-in thick geosynthetic clay liner (GCL).
- 2-ft thick layer of general fill.
- 5-ft thick layer of unsolidified waste.

The ORD and PRA caps were assumed to be sloped at 3 percent and to have maximum drainage length of 75 ft

Written by: MAO Date: 96 / 1 / 19 Reviewed by: RMD Date: 96 / 1 / 19
YY MM DD

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: 08

MATERIAL PROPERTIES

Table 1 below summarizes the properties of the original and alternative remedies materials used for the HELP model analyses.

Layer/ HELP Default Material Type	Layer(1) Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Initial Water Content (vol/vol)	Hydraulic Conductivity (cm/s)
ORD						
• Topsoil/8	VP	0.463	0.232	0.116	0.232	3.7×10^{-4}
• Compacted clay/25	VP	0.437	0.373	0.266	0.373	1.0×10^{-7} (2)
• General Fill/25	VP	0.437	0.373	0.266	0.373	3.6×10^{-6}
• Waste	VP	0.540	0.430	0.200	0.430	1.0×10^{-6}
PRA						
• Topsoil/8	VP	0.463	0.232	0.116	0.232	3.7×10^{-4}
• Geocomposite/20	LD	0.850	0.010	0.005	0.005	10.0
• Geomembrane/35	FML	0	0	0	0	2×10^{-13}
• GCL/17	BSL	0.750	0.747	0.400	0.750	3×10^{-9}
• General Fill/25	VP	0.437	0.373	0.266	0.373	3.6×10^{-6}
• Waste	VP	0.520	0.430	0.200	0.430	varies(2)

Notes: (1) VP = Vertical Percolation, LD = Lateral Drainage, FML = Flexible Membrane Liner, BSL = Barrier Soil Liner

(2) See text on next page

Written by: MAO Date: 95/1/19 Reviewed by: RWJ Date: 96/1/14

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: 08

Waste material properties reported in Table 1 were selected based on:

- information from the technical specifications for the original remedial design by HLA in 1991;
- default values from the HELP computer program;
- data reported in the Technical memorandum for the North Dike Area (TM-NDA) written by GeoSyntec Consultants in 1995;
- data reported in the Stabilization Evaluation Report (SER) by HLA in 1991; and
- data available in the original feasibility Study (FS) prepared in 1988 by Engineering-Science.

The potential effect of desiccation on the performance of the ORD cap was evaluated by assuming the compacted clay layer has degraded partially or fully as a result of desiccation. The degraded portion of the compacted clay layer was assumed to have a higher hydraulic conductivity than intact clay.

The hydraulic conductivity of the degraded portion was assumed to increase one to two orders of magnitude to become 1×10^{-6} to 1×10^{-5} cm/s.

The hydraulic conductivity of the waste in the PRA was varied from 5×10^{-7} to 1×10^{-5} cm/s to evaluate its effect on percolation through the waste.

Based on Giroud and Bonaparte [1989], the frequency of holes in the geomembrane was assumed to be 1 hole per acre. The geomembrane placement quality (i.e., contact with underlying soil) was assumed to be good.

Written by: MAO Date: 95 / 1 / 9 (YY MM DD) Reviewed by: RMD Date: 96 / 1 / 19 (YY MM DD)

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: 08

CLIMATOLOGICAL DATA

Climatological data including daily values of precipitation, solar radiation and temperature were generated synthetically by the HELP computer program for the nearest city to the Bailey site. HELP has default parameters for certain cities in the U.S. to allow synthetic generation of Climatological data. For evapotranspiration and temperature data, Lake Charles, LA, is the closest city to the Bailey site for which HELP can synthetically generate data. For precipitation data, Galveston, TX, is the closest city to the site to generate synthetic data for by HELP. Normal mean monthly precipitation and temperature values were input for Port Arthur, TX, to adjust the synthetically generated data. These monthly values were obtained from the National Oceanic and Atmospheric Administration (NOAA).

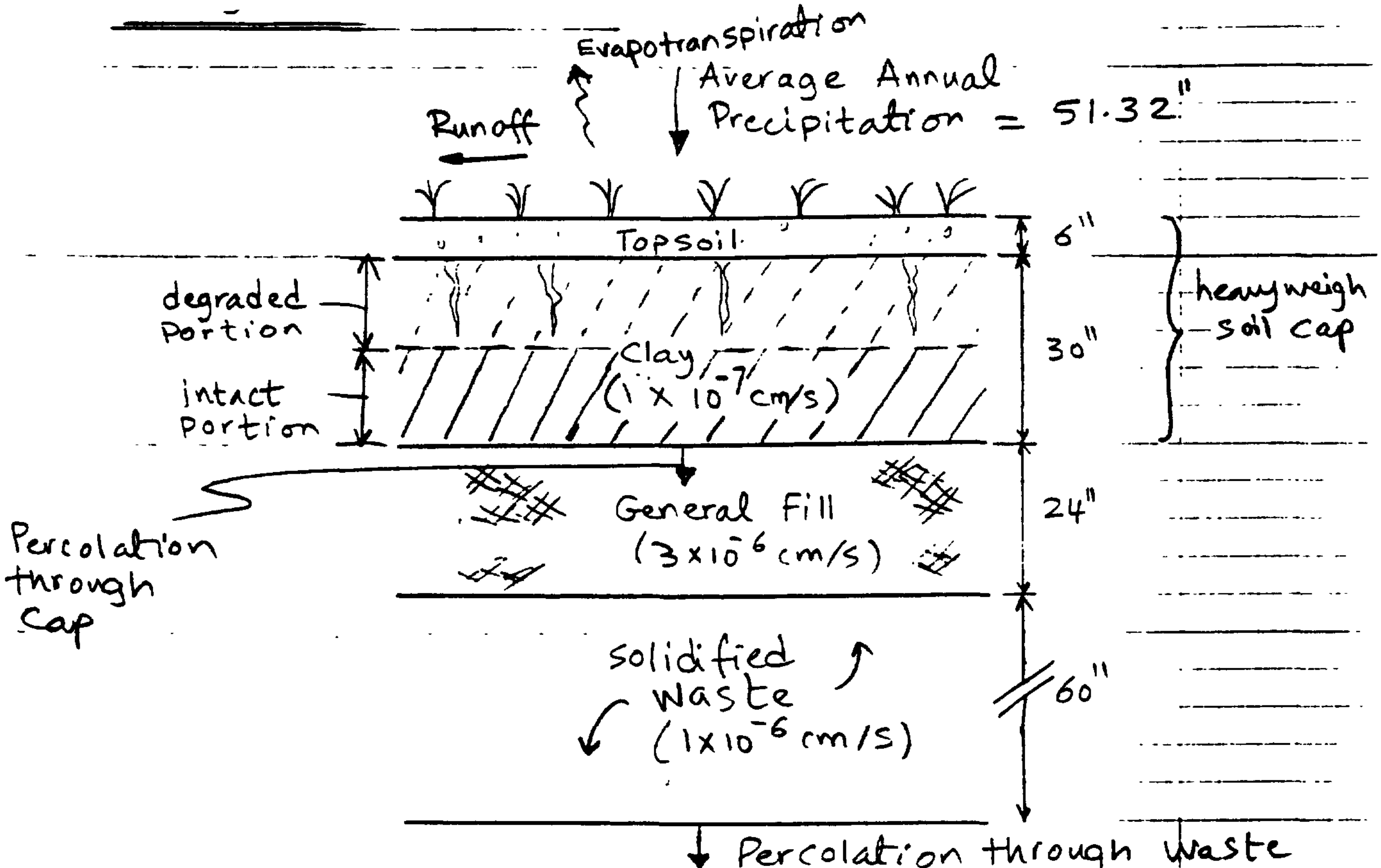
The latitude of the site was input as 29.4°

Written by: MAO Date: 96/1/19 Reviewed by: RNH Date: 96/1/19

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: Ø8

SUMMARY OF RESULTS

ORD



Run #	Degraded Portion Thickness (in.)	Intact Portion Thickness (in.)	Degraded Portion Hydraulic Conductivity (cm/s)	Average Annual Runoff (in.)	Average Annual Evapo-transpiration (in.)	Average Annual Percolation through waste (in.) (trend)(1)
1	0	30	—	19.832	31.470	0.194 (D)
2	30	0	1×10^{-6}	11.768	36.902	2.487 (F)
3	30	0	1×10^{-5}	5.078	36.995	8.876 (F)
6	12	18	1×10^{-6}	15.197	36.057	0.186 (D)
7	12	18	1×10^{-5}	13.783	37.459	0.187 (D)
8	24	6	1×10^{-6}	12.700	37.942	0.579 (F)
9	24	6	1×10^{-5}	10.449	39.779	0.952 (F)

(1) Trends: D = Decreasing; F = Fluctuating.

Written by: MAo Date: 96 / 1 / 19 Reviewed by: [signature] Date: 96 / 1 / 17

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: Ø8

Infiltration through the cap can be approximately estimated as:

$$I = P - E - R \quad (1)$$

where:

I = infiltration through the cap;
P = precipitation;
E = evapotranspiration; and
R = runoff.

or as

$$I = IW + S \quad (2)$$

where

IW = percolation through the waste
S = change in soil water storage

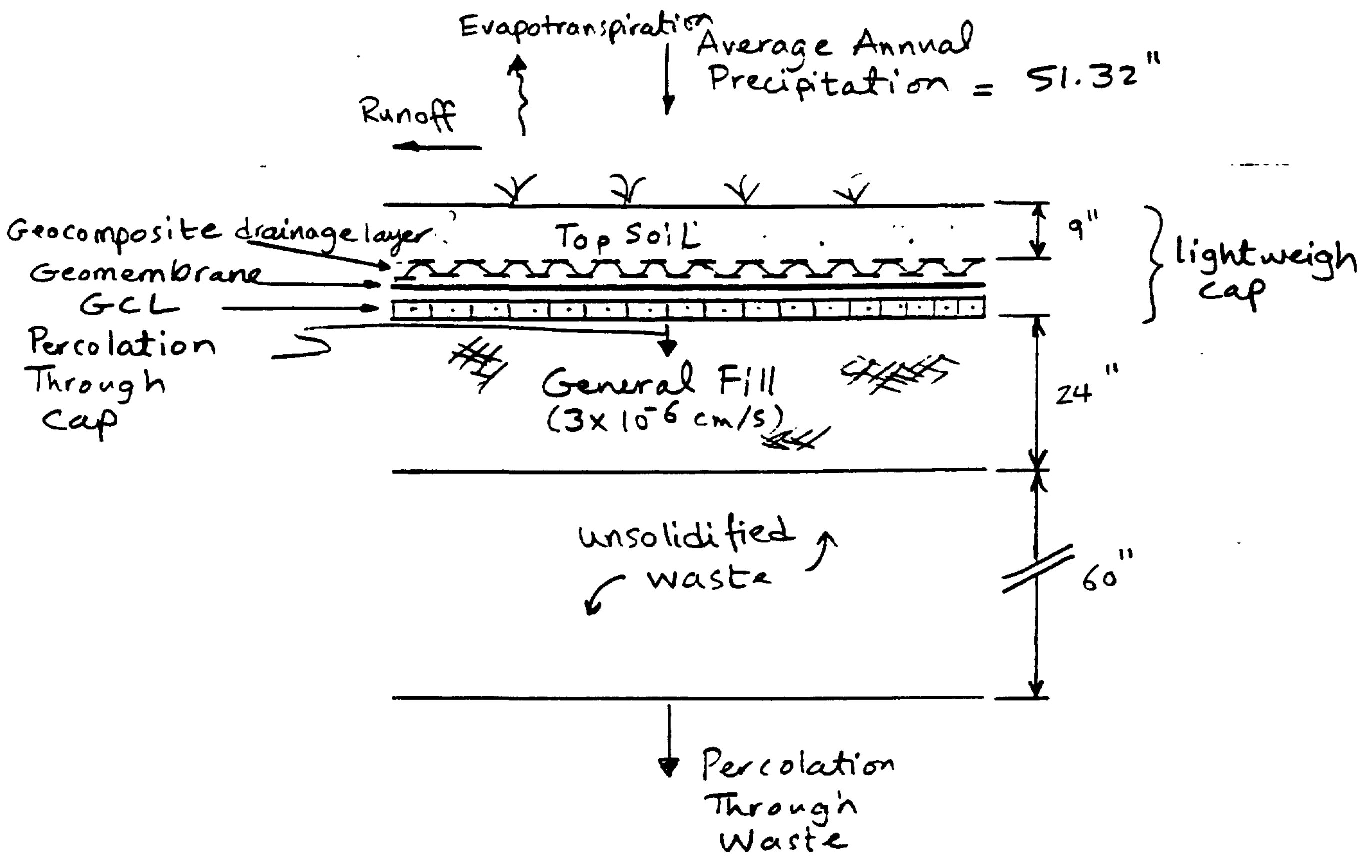
Run #	E (in.)	R (in.)	I (in.)(1)	IW (in.)	S (in.)	I (in.)(2)
1	31.470	19.832	0.018	0.194	-0.173	0.021
2	36.902	11.768	2.650	2.487	0.166	2.653
3	36.995	5.078	9.247	3.876	0.374	9.250
6	36.057	15.197	0.066	0.186	-0.117	0.070
7	37.459	13.783	0.078	0.187	-0.107	0.080
8	37.942	12.700	0.678	0.579	0.102	0.681
9	39.779	10.449	1.092	0.952	0.143	1.095

Notes: (1) Equation (1)
(2) Equation (2)
(3) $P = 51.32$ in.

Written by: MAO Date: 96/1/15 Reviewed by: [signature] Date: 96/1/19

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: #8

PRA



Run #	Hydraulic Conductivity of Waste (cm/s)	Average Annual Runoff (in.)	Average Annual Evapo-transpiration (in.)	Average Annual Percolation from Cap (in.)	Average Annual Lateral Drainage (in.)	Average Annual Percolation from waste (in.) (trend)(1)
4	5×10^{-7}	1.516	28.839	0	20.960	0.159 (D)
5	1×10^{-6}	1.516	28.239	0	20.960	0.201 (D)
10	1×10^{-5}	1.516	28.839	0	20.960	0.335 (D)

Notes: (1) D = Decreasing trend w/ time

REFERENCES

Schroeder, P.R., Lloyd, C.M., and Zappi, P.A., "The Hydrologic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3", U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., Report No. EPA/600/R-94/168a, Sep, 1994a.

Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L., "The Hydrologic Evaluation of Landfill Performance (HELP) Model, Engineering Documentation for Version 3", U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., Report No. EPA/600/R-94/168b, Sep 1994b, 116p.

Giroud, J.P., and Bonaparte, R., "Leakage Through Liners Constructed with Geomembranes, Part I: Geomembrane Liners," Geotextiles and Geomembranes, Vol. 8, No. 2, 1989, pp. 27-111

Written by: MAG Date: 96/1/19 Reviewed by: BAD Date: 96/1/19

Client: BSSC Project: Bailey Superfund Project/Proposal No.: GE3913 Task No.: Ø8

HELP MODEL OUTPUT

ORD: Runs 1, 2, 3, 6, 7, 8, and 9.

PRA: Runs 4, 5, and 10.

MAO 11/28/95 Checked RND 1/19/96

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.03  (31 DECEMBER 1994)                  **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************
```

PRECIPITATION DATA FILE: C:\HELP3\BAILEY1.D4
TEMPERATURE DATA FILE: C:\HELP3\BAILEY1.D7
SOLAR RADIATION DATA FILE: C:\HELP3\BAILEY1.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\BAILEY1.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\BAILEY1.D10
OUTPUT DATA FILE: C:\HELP3\BAILEY1.OUT

TIME: 15:55   DATE: 11/28/1995

****

TITLE: BAILEY SUPERFUND SITE, ORANGE COUNTY, TX, ORIG. REMEDY, RUN1

****

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
WERE SPECIFIED BY THE USER.

LAYER 1 (top soil)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.63
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2 (Clay)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =     30.00    INCHES
POROSITY                     =      0.4370 VOL/VOL
FIELD CAPACITY               =      0.3730 VOL/VOL
WILTING POINT                =      0.2660 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC
```

intact (as compacted)

LAYER 3 (general fill)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 25

```
THICKNESS                    =     24.00    INCHES
POROSITY                     =      0.4370 VOL/VOL
FIELD CAPACITY               =      0.3730 VOL/VOL
WILTING POINT                =      0.2660 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.359999990000E-05 CM/SEC
```

LAYER 4 (waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =     60.00    INCHES
POROSITY                     =      0.5400 VOL/VOL
FIELD CAPACITY               =      0.4300 VOL/VOL
WILTING POINT                =      0.2000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4300 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999997000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 75. FEET.

```
SCS RUNOFF CURVE NUMBER               =     74.80
FRACTION OF AREA ALLOWING RUNOFF      =    100.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE    =      1.000   ACRES
EVAPORATIVE ZONE DEPTH                =     30.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE     =     10.344   INCHES
```

UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.266	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	7.080	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	47.334	INCHES
TOTAL INITIAL WATER	=	47.334	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAKE CHARLES LOUISIANA ← closest city for which HELP can generate evapotranspiration data

MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	32
END OF GROWING SEASON (JULIAN DATE)	=	361
AVERAGE ANNUAL WIND SPEED	=	8.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	80.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	78.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GALVESTON TEXAS ← closest city for precip. data

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.18	3.71	2.93	4.05	4.50	3.96
5.37	5.45	6.13	3.63	4.33	4.55

modified for Port Arthur Tx based on NOAA data

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAKE CHARLES LOUISIANA ← closest city for temp. data

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
51.90	54.90	61.40	69.00	75.60	81.20
83.10	82.80	79.20	70.20	60.60	54.70

modified for Port Arthur, Tx based on NOAA data

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAKE CHARLES LOUISIANA ← closest city for S.R. data

STATION LATITUDE = 29.40 DEGREES

******

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.95	152278.531	100.00
RUNOFF	14.545	52799.449	34.67
EVAPOTRANSPIRATION	28.859	104759.250	68.79
PERC./LEAKAGE THROUGH LAYER 4	0.698056	253 943	1.66
CHANGE IN WATER STORAGE	-2.153	-7814.171	-5.13
SOIL WATER AT START OF YEAR	47.334	171822.141	
SOIL WATER AT END OF YEAR	45.181	164007.969	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.063	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	57.45	208543.469	100.00
RUNOFF	26.097	94733.523	45.43
EVAPOTRANSPIRATION	32.[illegible]94	118678.844	56.91
PERC./LEAKAGE THROUGH LAYER 4	0.522178	1895.507	0.91
CHANGE IN WATER STORAGE	-1.863	-6764.375	-3.24
SOIL WATER AT START OF YEAR	45.181	164007.969	
SOIL WATER AT END OF YEAR	43.318	157243.594	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.040	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.03	181608.906	100.00
RUNOFF	18.170	65955.609	36.32
EVAPOTRANSPIRATION	29.732	107925.906	59.43
PERC./LEAKAGE THROUGH LAYER 4	0.422371	1533.206	0.84
CHANGE IN WATER STORAGE	1.706	6194.225	3.41
SOIL WATER AT START OF YEAR	43.318	157243.594	
SOIL WATER AT END OF YEAR	45.024	163437.812	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.041	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.11	167379.312	100.00
RUNOFF	15.366	55777.965	33.32
EVAPOTRANSPIRATION	30.392	110323.398	65.91
PERC./LEAKAGE THROUGH LAYER 4	0.362277	1315.067	0.79
CHANGE IN WATER STORAGE	-0.010	-37.097	-0.02
SOIL WATER AT START OF YEAR	45.024	163437.812	
SOIL WATER AT END OF YEAR	45.014	163400.719	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.38	128429.406	100.00
RUNOFF	7.882	28612.070	22.28
EVAPOTRANSPIRATION	27.470	99715.133	77.64
PERC./LEAKAGE THROUGH LAYER 4	0.315266	1144.417	0.89
CHANGE IN WATER STORAGE	-0.287	-1042.193	-0.81
SOIL WATER AT START OF YEAR	45.014	163400.719	
SOIL WATER AT END OF YEAR	44.727	162358.531	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.025	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	55.19	200339.687	100.00
RUNOFF	20.711	75181.648	37.53
EVAPOTRANSPIRATION	34.956	126890.711	63.34
PERC./LEAKAGE THROUGH LAYER 4	0.278915	1012.462	0.51
CHANGE IN WATER STORAGE	-0.756	-2745.182	-1.37
SOIL WATER AT START OF YEAR	44.727	162358.531	
SOIL WATER AT END OF YEAR	43.971	159613.344	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.042	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	63.94	232102.141	100.00
RUNOFF	28.973	105171.062	45.31
EVAPOTRANSPIRATION	34.413	124919.891	53.82
PERC./LEAKAGE THROUGH LAYER 4	0.250866	910.644	0.39
CHANGE IN WATER STORAGE	0.303	1100.587	0.47
SOIL WATER AT START OF YEAR	43.971	159613.344	
SOIL WATER AT END OF YEAR	44.274	160713.937	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.042	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	53.00	192390.031	100.00
RUNOFF	26.686	96871.367	50.35
EVAPOTRANSPIRATION	26.342	95621.617	49.70
PERC./LEAKAGE THROUGH LAYER 4	0.228305	828.746	0.43
CHANGE IN WATER STORAGE	-0.257	-931.761	-0.48
SOIL WATER AT START OF YEAR	44.274	160713.937	
SOIL WATER AT END OF YEAR	44.017	159782.172	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	0.059	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.58	179975.422	100.00
RUNOFF	18.368	66674.156	37.05
EVAPOTRANSPIRATION	31.579	114632.961	63.69
PERC./LEAKAGE THROUGH LAYER 4	0.208655	757.417	0.42
CHANGE IN WATER STORAGE	-0.576	-2089.205	-1.16
SOIL WATER AT START OF YEAR	44.017	159782.172	
SOIL WATER AT END OF YEAR	43.442	157692.969	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.088	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	57.17	207527.062	100.00
RUNOFF	25.741	93440.000	45.03
EVAPOTRANSPIRATION	30.924	112252.602	54.09
PERC./LEAKAGE THROUGH LAYER 4	0.192582	699.073	0.34
CHANGE IN WATER STORAGE	0.313	1135.386	0.55
SOIL WATER AT START OF YEAR	43.442	157692.969	
SOIL WATER AT END OF YEAR	43.754	158828.359	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00